Complete Summary

GUIDELINE TITLE

ACR Appropriateness Criteria® head trauma.

BIBLIOGRAPHIC SOURCE(S)

Davis PC, Brunberg JA, De La Paz RL, Dormont D, Jordan JE, Mukherji SK, Seidenwrum DJ, Turski PA, Wippold FJ II, Zimmerman RD, Sloan MA, Expert Panel on Neurologic Imaging. ACR Appropriateness Criteria® head trauma. [online publication]. Reston (VA): American College of Radiology (ACR); 2008. 13 p. [51 references]

GUIDELINE STATUS

This is the current release of the guideline.

This guideline updates a previous version: Davis PC, Seidenwurm DJ, Brunberg JA, De La Paz RL, Dormont PD, Hackney DB, Jordan JE, Karis JP, Mukherji SK, Turski PA, Wippold FJ, Zimmermam RD, McDermot MW, Sloan MA, Expert Panel on Neurologic Imaging. Head trauma. [online publication]. Reston (VA): American College of Radiology (ACR); 2006. 12 p. [48 references]

The appropriateness criteria are reviewed annually and updated by the panels as needed, depending on introduction of new and highly significant scientific evidence.

COMPLETE SUMMARY CONTENT

SCOPE

DISEASE/CONDITION(S)

Head trauma

GUIDELINE CATEGORY

Diagnosis
Evaluation

CLINICAL SPECIALTY

Emergency Medicine
Internal Medicine
Neurological Surgery
Neurology
Radiology

INTENDED USERS

Health Plans
Hospitals
Managed Care Organizations
Physicians
Utilization Management

GUIDELINE OBJECTIVE(S)

To evaluate the appropriateness of initial radiologic examinations for patients with head trauma

TARGET POPULATION

Patients with head trauma

INTERVENTIONS AND PRACTICES CONSIDERED

1. Computed tomography (CT)
    - Head, without contrast
    - Head, without and with contrast
    - Cervical spine without contrast
2. Computed tomography angiography (CTA), head and neck
3. Magnetic resonance imaging (MRI), head
    - Without contrast
    - Without and with contrast
4. Functional MRI (fMRI), head
5. Magnetic resonance angiography (MRA), head and neck
    - Without contrast
    - Without and with contrast
6. X-ray
    - Cervical spine
    - Head
7. Invasive (INV), cervicocerebral arteriography
8. Nuclear medicine (NUC), technetium (Tc)-99m hexamethylpropyleneamine oxime (HMPAO) single-photon emission computed tomography (SPECT)
9. Fluorodeoxyglucose-positron emission tomography (FDG-PET)

10. Ultrasound (US), transcranial with Doppler

MAJOR OUTCOMES CONSIDERED

Utility of radiologic examinations in differential diagnosis

METHODOLOGY

METHODS USED TO COLLECT/SELECT EVIDENCE

Searches of Electronic Databases

DESCRIPTION OF METHODS USED TO COLLECT/SELECT THE EVIDENCE

The guideline developer performed literature searches of peer-reviewed medical journals, and the major applicable articles were identified and collected.

NUMBER OF SOURCE DOCUMENTS

Not stated

METHODS USED TO ASSESS THE QUALITY AND STRENGTH OF THE EVIDENCE

Weighting According to a Rating Scheme (Scheme Not Given)

RATING SCHEME FOR THE STRENGTH OF THE EVIDENCE

Not stated

METHODS USED TO ANALYZE THE EVIDENCE

Systematic Review with Evidence Tables

DESCRIPTION OF THE METHODS USED TO ANALYZE THE EVIDENCE

One or two topic leaders within a panel assume the responsibility of developing an evidence table for each clinical condition, based on analysis of the current literature. These tables serve as a basis for developing a narrative specific to each clinical condition.

METHODS USED TO FORMULATE THE RECOMMENDATIONS

Expert Consensus (Delphi)

DESCRIPTION OF METHODS USED TO FORMULATE THE RECOMMENDATIONS

Since data available from existing scientific studies are usually insufficient for meta-analysis, broad-based consensus techniques are needed to reach agreement in the formulation of the appropriateness criteria. The American College of Radiology (ACR) Appropriateness Criteria panels use a modified Delphi technique to arrive at consensus. Serial surveys are conducted by distributing questionnaires to consolidate expert opinions within each panel. These questionnaires are distributed to the participants along with the evidence table and narrative as developed by the topic leader(s). Questionnaires are completed by the participants in their own professional setting without influence of the other members. Voting is conducted using a scoring system from 1-9, indicating the least to the most appropriate imaging examination or therapeutic procedure. The survey results are collected, tabulated in anonymous fashion, and redistributed after each round. A maximum of three rounds is conducted and opinions are unified to the highest degree possible. Eighty percent agreement is considered a consensus. This modified Delphi technique enables individual, unbiased expression, is economical, easy to understand, and relatively simple to conduct.

If consensus cannot be reached by the Delphi technique, the panel is convened and group consensus techniques are utilized. The strengths and weaknesses of each test or procedure are discussed and consensus reached whenever possible. If "No consensus" appears in the rating column, reasons for this decision are added to the comment sections.

RATING SCHEME FOR THE STRENGTH OF THE RECOMMENDATIONS

Not applicable

COST ANALYSIS

A formal cost analysis was not performed and published cost analyses were not reviewed.

METHOD OF GUIDELINE VALIDATION

Internal Peer Review

DESCRIPTION OF METHOD OF GUIDELINE VALIDATION

Criteria developed by the Expert Panels are reviewed by the American College of Radiology (ACR) Committee on Appropriateness Criteria.

RECOMMENDATIONS

MAJOR RECOMMENDATIONS

ACR Appropriateness Criteria®

Clinical Condition: Head Trauma

Variant 1: Minor or mild acute closed head injury (GCS >13), without risk factors or neurologic deficit.

Radiologic Procedure	Rating	Comments	RRL*
CT head without contrast	7	Known to be low yield.	Med
X-ray and/or CT cervical spine without contrast	5	See ACR Appropriateness Criteria® on Suspected Spine Trauma.	Med
MRI head without contrast	4		None
MRA head and neck without contrast	3	Rarely indicated with mild trauma.	None
MRA head and neck without and with contrast	3		None
CT head without and with contrast	3		Med
CTA head and neck	3	Rarely indicated with mild trauma.	Med
MRI head without and with contrast	2		None
X-ray head	1		Min
FDG-PET head	1		High
US transcranial with Doppler	1		None
INV arteriography cervicocerebral	1		Med
NUC Tc-99m HMPAO SPECT head	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 2: Minor or mild acute closed head injury, focal neurologic deficit and/or risk factors.

Radiologic Procedure	Rating	Comments	RRL*
CT head without contrast	9		Med
MRI head without contrast	6	For problem solving.	None
X-ray and/or CT cervical spine without contrast	6	See ACR Appropriateness Criteria® on Suspected Spine Trauma.	Med
MRA head and neck without contrast	5	If vascular injury is suspected. For problem solving.	None
MRA head and neck without and with contrast	5	If vascular injury is suspected. For problem solving. See comments regarding contrast in the text below under "Anticipated Exceptions."	None
CTA head and neck	5	If vascular injury is suspected. For problem solving.	Med
MRI head without and with contrast	3		None
CT head without and with contrast	2		Med
NUC Tc-99m HMPAO SPECT head	1		High
FDG-PET head	1		High
US transcranial with Doppler	1		None
X-ray head	1		Min
INV arteriography cervicocerebral	1		Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 3: Moderate or severe acute closed head injury.

Radiologic Procedure	Rating	Comments	RRL*
CT head without contrast	9		Med
X-ray and/or CT cervical spine without contrast	8	See ACR Appropriateness Criteria® on Suspected Spine Trauma.	Med
MRI head without contrast	6		None
MRA head and neck without contrast	5		None
MRA head and neck without and with contrast	5	See comments regarding contrast in the text below under "Anticipated Exceptions."	None
CTA head and neck	5		Med
CT head without and with contrast	2		Med
MRI head without and with contrast	2		None
X-ray head	2		Min
US transcranial with Doppler	1		None
FDG-PET head	1		High
INV arteriography cervicocerebral	1		Med
NUC Tc-99m HMPAO SPECT head	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 4: Mild or moderate acute closed head injury, child <2 years old.

Radiologic Procedure	Rating	Comments	RRL*

Radiologic Procedure	Rating	Comments	RRL*
CT head without contrast	9		High
X-ray and/or CT cervical spine without contrast	7	See ACR Appropriateness Criteria® on Suspected Spine Trauma.	High
MRI head without contrast	7	Diffusion weighted imaging especially helpful for non-accidental trauma.	None
X-ray head	5		Min
MRI head without and with contrast	4	Potentially useful in suspected non-accidental trauma. See comments regarding contrast in the text below under "Anticipated Exceptions."	None
MRA head and neck without contrast	4	If vascular abnormality suspected.	None
MRA head and neck without and with contrast	4	If vascular abnormality suspected. See comments regarding contrast in the text below under "Anticipated Exceptions."	None
CTA head and neck	4	If vascular abnormality is suspected.	Med
CT head without and with contrast	2		High
FDG-PET head	1		High
NUC Tc-99m HMPAO SPECT head	1		High
US transcranial with Doppler	1		None
INV arteriography cervicocerebral	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 5: Subacute or chronic closed head injury with cognitive and/or neurologic deficit(s).

Radiologic Procedure	Rating	Comments	RRL*
MRI head without contrast	8		None
CT head without contrast	6		Med
NUC Tc-99m HMPAO SPECT head	4	For selected cases.	High
FDG-PET head	4	For selected cases.	High
MRA head and neck without contrast	4	For selected cases.	None
MRA head and neck without and with contrast	4	For selected cases. See comments regarding contrast in the text below under "Anticipated Exceptions."	None
CTA head and neck	4	For selected cases.	Med
MRI head without and with contrast	3		None
CT head without and with contrast	2		Med
X-ray and/or CT cervical spine without contrast	2	Assuming there are no spinal neurologic deficits. See ACR Appropriateness Criteria® on Suspected Spine Trauma.	Med
X-ray head	2		Min
MRI functional (fMRI) head	2		None
US transcranial with Doppler	1		None
INV arteriography cervicocerebral	1		Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 6: Closed head injury, rule out carotid or vertebral artery dissection.

Radiologic Procedure	Rating	Comments	RRL*
MRA head and neck without contrast	8	Add T1 neck images.	None
MRA head and neck without and with contrast	8	Add T1 neck images. See comments regarding contrast in the text below under "Anticipated Exceptions."	None
MRI head without contrast	8	Include diffusion-weighted images.	None
CT head without contrast	8		Med
CTA head and neck	8		Med
CT head without and with contrast	6	Consider perfusion.	Med
INV arteriography cervicocerebral	6	For problem solving.	Med
MRI head without and with contrast	6	See comments regarding contrast in the text below under "Anticipated Exceptions."	None
X-ray and/or CT cervical spine without contrast	5	See ACR Appropriateness Criteria® on Suspected Spine Trauma.	Med
X-ray head	2		Min
NUC Tc-99m HMPAO SPECT head	1		High
US transcranial with Doppler	1		None
FDG-PET head	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 7: Penetrating injury, stable, neurologically intact.

Radiologic Procedure	Rating	Comments	RRL*

Radiologic Procedure	Rating	Comments	RRL*
CT head without contrast	9		Med
X-ray and/or CT cervical spine without contrast	8	If neck or C-spine is site of injury. See ACR Appropriateness Criteria® on Suspected Spine Trauma.	Med
X-ray head	8	If calvarium is site of injury.	Min
CTA head and neck	7		Med
MRA head and neck without contrast	6	If no MRI contraindication.	None
MRA head and neck without and with contrast	6	If no MRI contraindication. See comments regarding contrast in the text below under "Anticipated Exceptions."	None
INV arteriography cervicocerebral	5	If vascular injury is suspected.	Med
MRI head without contrast	5	If no MRI contraindication.	None
CT head without and with contrast	4	Consider perfusion.	Med
MRI head without and with contrast	4	If no MRI contraindication. See comments regarding contrast in the text below under "Anticipated Exceptions."	None
US transcranial with Doppler	1		None
NUC Tc-99m HMPAO SPECT head	1		High
FDG-PET head	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Variant 8: Skull fracture.

Radiologic Procedure	Rating	Comments	RRL*
CT head without contrast	9		Med
CTA head and neck	7	If vascular injury suspected.	Med
MRI head without contrast	6		None
X-ray and/or CT cervical spine without contrast	6	See ACR Appropriateness Criteria® on Suspected Spine Trauma.	Med
X-ray head	5	For selected cases.	Min
MRI head without and with contrast	4	Useful if infection suspected. See comments regarding contrast in the text below under "Anticipated Exceptions."	None
CT head without and with contrast	4		Med
MRA head and neck without contrast	4		None
MRA head and neck without and with contrast	4	See comments regarding contrast in the text below under "Anticipated Exceptions."	None
US transcranial with Doppler	1		None
NUC Tc-99m HMPAO SPECT head	1		High
INV arteriography cervicocerebral	1		Med
FDG-PET head	1		High
Rating Scale: 1=Least appropriate, 9=Most appropriate			***Relative Radiation Level**

Note: Abbreviations used in the tables are listed at the end of the "Major Recommendations" field.

Summary of Literature Review

Craniocerebral injuries are a common cause of hospital admission following trauma, and are associated with significant long-term morbidity and mortality, particularly in the adolescent and young adult population. Neuroimaging plays an essential role in identifying and characterizing these brain injuries. Computed tomography (CT) remains essential for detecting lesions that require immediate neurosurgical intervention (i.e., acute subdural hematoma) as well as those that require in-hospital observation and medical management. For patients with minor head injury (Glasgow Coma Scale [GCS] score of 13-15), the New Orleans Criteria and the Canadian CT Head Rule are clinical guidelines with high sensitivity for detecting injuries that require neurosurgical intervention, and they offer a potential reduction in unnecessary CT scans.

Other imaging modalities, such as magnetic resonance imaging (MRI), depict nonsurgical pathology not visible on CT. Single photon emission computed tomography (SPECT), positron emission tomography (PET), and transcranial Doppler (TCD) have a complementary role in the assessment of brain injury. Because cervical spine trauma may accompany a head injury, cervical spine imaging is indicated for patients with head injury who have signs, symptoms, or a mechanism of injury that might result in spinal injury, and in those who are neurologically impaired.

Skull Radiography

One study developed and prospectively tested a management strategy for selecting patients who may benefit from skull radiography following head trauma was and offered recommendations for selecting patients who should receive CT scanning following head injury. The effect of that study was to shift the focus of neuroimaging of head trauma away from skull radiography and toward recognition of intracranial pathology as demonstrated by CT scanning. Skull radiography is useful for imaging of calvarial fractures, penetrating injuries, and radiopaque foreign bodies.

Computed Tomography

CT advantages for evaluation of the head-injured patient include its sensitivity for demonstrating mass effect, ventricular size and configuration, bone injuries, and acute hemorrhage regardless of location (i.e., parenchymal, subarachnoid, subdural, or epidural spaces). Other advantages include its widespread availability, rapidity of scanning, and compatibility with other medical and life support devices. Its limitations include insensitivity in detecting small and predominantly nonhemorrhagic lesions associated with trauma such as contusion, particularly when adjacent to bony surfaces (e.g., frontal lobes adjacent to the orbital roof, anterior temporal lobe adjacent to the greater sphenoid wing). Likewise, diffuse axonal injuries (DAIs) that result in small focal lesions throughout the cerebral hemispheres, corpus callosum, and upper brainstem and cerebellum often go undetected on CT. CT is relatively insensitive for detecting increased intracranial pressure or cerebral edema and for early demonstration of hypoxic-ischemic encephalopathy (HIE) that may accompany moderate or severe head injury. Potential risks of unnecessary exposure to ionizing radiation warrant judicious patient selection for CT scanning as well as radiation dose management.

There is now a general consensus that patients identified as having moderate or high risk for intracranial injury should undergo early postinjury noncontrast CT for evidence of intracerebral hematoma, midline shift, or increased intracranial pressure. A number of clinical criteria are used to predict patient risk categories for intracranial injury. There is an inverse relationship between declining clinical or neurologic status as described by the GCS and the incidence and severity of CT abnormalities related to head injury.

Although experienced physicians can often predict the likelihood of an abnormal CT scan in moderate or severe head injury, clinical selection criteria of patients with minor or mild injury (i.e., GCS score $\geq$13) who harbor significant intracranial pathology and/or require acute surgical intervention have been problematic. Rapid CT scanning is readily available in most hospitals that treat head-injured patients; thus the routine use of CT has been advocated as a screening tool to triage minor or mild head-injured patients who require hospital admission or surgical intervention from those who can be safely discharged without hospital admission. Although CT triage of head-injured patients who require hospital admission offers a reduced burden on inpatient hospital services at lower cost than routine hospital admission for observation, the result is greater CT use in the emergency setting. In the minor head injury setting with a GCS score of 15, the New Orleans Criteria found a 100% sensitivity for CT identification of an acute trauma lesion using risk factors of headache, vomiting, drug or alcohol intoxication, older than age 60, short-term memory deficit, physical findings of supraclavicular trauma, and/or seizure. One study reported 100% sensitivity for detecting neurosurgical and/or clinically important brain injury in subjects with a GCS score of 13-15 based on high-risk factors of failure to reach a GCS score of 15 within 2 hours, suspected open skull fracture, 2 or more vomiting episodes, sign of basal skull fracture, or age $\geq$65 years.

Clinical criteria for scanning of children with head injury have been less reliable than those for adults, particularly for children younger than age two. For this reason, more liberal use of CT scanning has been suggested for pediatric patients. On the other hand, this must be balanced with the higher risk of radiation exposure in childhood via judicious patient selection for scanning as well as management of radiation dose. Noncontrast head CT plays an essential role in the evaluation of children with suspected physical injury from child abuse; appropriateness criteria for imaging of child abuse have already been described (see the pediatric sections of the American College of Radiology [ACR] Appropriateness Criteria®).

Early and sometimes repeated CT scanning may be required in cases of clinical or neurologic deterioration, especially in the first 72 hours after head injury, to detect delayed hematoma, hypoxic-ischemic lesions, or cerebral edema. CT has a role in subacute or chronic head injury for depicting atrophy, focal encephalomalacia, hydrocephalus, and chronic subdural hematoma.

Cerebral Angiography

Since the development of CT in the mid-1970s, the need for cerebral angiography for head injury has dramatically declined. Cerebral angiography has a role in demonstrating and managing traumatic vascular injuries such as pseudoaneurysm, dissection, or diagnosis and neurointerventional treatment of uncontrolled hemorrhage. Vascular injuries typically occur with penetrating trauma (i.e., gunshot wound or stabbing), basal skull fracture, or trauma to the neck.

Dynamic spiral CT angiography (CTA) and magnetic resonance angiography (MRA) have a role as less invasive screening tools for detection of traumatic vascular lesions. MRA and fat-suppressed Tl-weighted MR or CTA may reveal carotid or vertebral dissection, although angiography remains the gold standard for dissection depiction. Cerebral infarction is an infrequent accompaniment to head injury, and patterns of infarction suggest that direct vascular compression related to intracranial mass lesions is the most common underlying mechanism.

Magnetic Resonance Imaging

Although the role of MRI in imaging of head trauma is growing, its use is hindered by its limited availability in the acute trauma setting, long imaging times, sensitivity to patient motion, incompatibility with various medical and life support devices, and relative insensitivity to subarachnoid hemorrhage. Other factors include the need for MRI-specific monitoring equipment and ventilators, and the risk of scanning patients with certain indwelling devices (e.g., cardiac pacemaker, cerebral aneurysm clip) or occult foreign bodies. In part, these limitations can be overcome by situating MRI scanners close to emergency care areas with appropriate design and equipment for managing acutely injured patients. MRI advances such as open-bore geometry, faster imaging sequences, and improved patient monitoring equipment allow a greater role for MRI in closed head injuries.

MRI is very sensitive for detecting and characterizing of subacute and chronic brain injuries. The number, size, and location of MR abnormalities in subacute head injury have been used to predict the recovery outcome of post-traumatic vegetative state. While CT is sensitive for detecting injuries requiring a change in treatment, MRI is also used for acute head-injured patients with nonsurgical, medically stable pathology. Hemosiderin-sensitive T2-weighted gradient echo sequences are helpful for imaging small or subacute or chronic hemorrhages. Diffusion sequences improve detection of acute infarction associated with head injury. Fluid attenuated inversion recovery (FLAIR) images are more sensitive than conventional MRI sequences for depicting subarachnoid hemorrhage and for lesions bordered by cerebrospinal fluid (CSF). MRA is helpful for screening of vascular lesions such as thromboses, pseudoaneurysms, or dissection. One study found that the addition of gadolinium enhancement offered no significant advantage for lesion detection or characterization compared with noncontrast MRI images in head-injury patients.

The soft tissue detail offered by MRI is superior to that of CT for depicting nonhemorrhagic primary lesions such as contusions, for detecting secondary effects of trauma such as edema and hypoxic-ischemic encephalopathy, and for imaging of DAI. DAI results from a shear-strain pattern of acceleration-deceleration with characteristic lesions in increasing order of injury severity in the: (1) cerebral white matter and gray-white matter junction, (2) corpus callosum, particularly the splenium, and (3) dorsal upper brain stem and cerebellum.

Although management of surgical injuries is not likely to be altered by the substitution of MRI for CT, superior depiction of nonsurgical lesions with MRI may affect medical management and predict the degree of neurologic recovery. Diffusion-weighted MRI and apparent diffusion coefficient (ADC) mapping depict cytotoxic injury almost immediately. In acute brain trauma, focal contusion and

DAI may show restricted diffusion and evolve over time to atrophy or encephalomalacia. Perfusion imaging with CT or MRI may prove helpful as a marker for disorders of vascular autoregulation or ischemia. Diffusion tensor imaging and MR spectroscopy (MRS) are ancillary tools that may offer additional insight into the biochemical and structural patterns of injury following head trauma, as well as prognosis.

Other Imaging Modalities

A few reports of selected head-injury subjects suggest a role for functional imaging techniques (SPECT, PET, xenon-enhanced CT, functional MRI) to assess cognitive and neuropsychologic disturbances as well as recovery following head trauma. SPECT studies may reveal focal areas of hypoperfusion that are discordant with findings of MRI or CT. On the basis of these results, some investigators suggest that these functional imaging techniques may explain or predict post-injury neuropsychologic and cognitive deficits that are not explained by MRI or CT abnormalities. Furthermore, focal lesions demonstrated by SPECT offer objective evidence of organic injury in patients whose neuroimaging studies are otherwise normal. One study found that a pattern of global reduction of cerebral blood flow detected by SPECT predicted a poor likelihood of recovery for patients who are in a persistent vegetative state due to head injury. SPECT and PET do not provide the anatomic detail or image resolution of CT or MRI for demonstrating acute or neurosurgical lesions of closed head injury, so their use is generally limited to subacute or chronic patients.

Transcranial Doppler sonography offers a noninvasive bedside evaluation of cerebral blood flow velocity and resistance in the major proximal vessels of the circle of Willis. Several investigators have suggested that TCD can be used to monitor early changes in blood flow velocities that may relate to vasospasm, hypervolemia, low velocity state, or edema, especially in management of the acutely brain-injured patient.

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF, also known as nephrogenic fibrosing dermopathy) was first identified in 1997 and has recently generated substantial concern among radiologists, referring doctors and lay people. Until the last few years, gadolinium-based MR contrast agents were widely believed to be almost universally well tolerated, extremely safe and non-nephrotoxic, even when used in patients with impaired renal function. All available experience suggests that these agents remain generally very safe, but recently some patients with renal failure who have been exposed to gadolinium contrast agents (the percentage is unclear) have developed NSF, a syndrome that can be fatal. Further studies are necessary to determine what the exact relationships are between gadolinium-containing contrast agents, their specific components and stoichiometry, patient renal function and NSF. Current theory links the development of NSF to the administration of relatively high doses (e.g., >0.2mM/kg) and to agents in which the gadolinium is least strongly chelated. The U.S. Food and Drug Administration (FDA) has recently issued a "black box" warning concerning these contrast agents (http://www.fda.gov/cder/drug/InfoSheets/HCP/gcca_200705HCP.pdf).

This warning recommends that, until further information is available, gadolinium contrast agents should not be administered to patients with either acute or significant chronic kidney disease (estimated glomerular filtration rate [GFR] <30 mL/min/1.73m^2), recent liver or kidney transplant or hepato-renal syndrome, unless a risk-benefit assessment suggests that the benefit of administration in the particular patient clearly outweighs the potential risk(s).

Abbreviations

- ACR, American College of Radiology
- C-spine, cervical spine
- CT, computed tomography
- CTA, computed tomography angiography
- FDG-PET, fluorodeoxyglucose-positron emission tomography
- GCS, Glasgow Coma Scale
- HMPAO, hexamethylpropyleneamine oxime
- INV, invasive
- Med, medium
- Min, minimal
- MRA, magnetic resonance angiography
- MRI, magnetic resonance imaging
- NUC, nuclear medicine
- SPECT, single photon emission tomography
- Tc, technetium
- US, ultrasound

Relative Radiation Level	Effective Dose Estimated Range
None	0
Minimal	<0.1 mSv
Low	0.1-1 mSv
Medium	1-10 mSv
High	10-100 mSv

CLINICAL ALGORITHM(S)

None provided

EVIDENCE SUPPORTING THE RECOMMENDATIONS

TYPE OF EVIDENCE SUPPORTING THE RECOMMENDATIONS

The recommendations are based on analysis of the current literature and expert panel consensus.

BENEFITS/HARMS OF IMPLEMENTING THE GUIDELINE RECOMMENDATIONS

POTENTIAL BENEFITS

Selection of appropriate radiologic imaging procedures for evaluation of patients with head trauma

POTENTIAL HARMS

- Potential risks of unnecessary exposure to ionizing radiation warrant judicious patient selection for CT scanning as well as radiation dose management.
- Some patients with renal failure who have been exposed to gadolinium contrast agents (the percentage is unclear) have developed nephrogenic systemic fibrosis (NSF), a syndrome that can be fatal. The U.S. Food and Drug Administration (FDA) has recently issued a "black box" warning concerning these contrast agents. This warning recommends that, until further information is available, gadolinium contrast agents should not be administered to patients with either acute or significant chronic kidney disease (estimated glomerular filtration rate [GFR] <30 mL/min/1.73m^2), recent liver or kidney transplant or hepato-renal syndrome, unless a risk-benefit assessment suggests that the benefit of administration in the particular patient clearly outweighs the potential risk(s).

Relative Radiation Level (RRL)

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Additional information regarding radiation dose assessment for imaging examinations can be found in the American College of Radiology (ACR) Appropriateness Criteria® Radiation Dose Assessment Introduction document (see "Availability of Companion Documents" field).

QUALIFYING STATEMENTS

QUALIFYING STATEMENTS

An American College of Radiology (ACR) Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those exams generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the U.S. Food and Drug Administration (FDA) have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

IMPLEMENTATION OF THE GUIDELINE

DESCRIPTION OF IMPLEMENTATION STRATEGY

An implementation strategy was not provided.

IMPLEMENTATION TOOLS

Personal Digital Assistant (PDA) Downloads

For information about availability, see the "Availability of Companion Documents" and "Patient Resources" fields below.

INSTITUTE OF MEDICINE (IOM) NATIONAL HEALTHCARE QUALITY REPORT CATEGORIES

IOM CARE NEED

Getting Better

IOM DOMAIN

Effectiveness

IDENTIFYING INFORMATION AND AVAILABILITY

BIBLIOGRAPHIC SOURCE(S)

Davis PC, Brunberg JA, De La Paz RL, Dormont D, Jordan JE, Mukherji SK, Seidenwrum DJ, Turski PA, Wippold FJ II, Zimmerman RD, Sloan MA, Expert Panel on Neurologic Imaging. ACR Appropriateness Criteria® head trauma. [online publication]. Reston (VA): American College of Radiology (ACR); 2008. 13 p. [51 references]

ADAPTATION

Not applicable: The guideline was not adapted from another source.

DATE RELEASED

1996 (revised 2008)

GUIDELINE DEVELOPER(S)

American College of Radiology - Medical Specialty Society

SOURCE(S) OF FUNDING

The American College of Radiology (ACR) provided the funding and the resources for these ACR Appropriateness Criteria®.

GUIDELINE COMMITTEE

Committee on Appropriateness Criteria, Expert Panel on Neurologic Imaging

COMPOSITION OF GROUP THAT AUTHORED THE GUIDELINE

Panel Members: Patricia C. Davis, MD; James A. Brunberg, MD; Robert Louis De La Paz, MD; Pr. Didier Dormont; John E. Jordan, MD; Suresh Kumar Mukherji, MD; David J. Seidenwurm, MD; Patrick A Turski, MD; Franz J Wippold II, MD; Robert D Zimmerman, MD; Michael A. Sloan, MD, MS

FINANCIAL DISCLOSURES/CONFLICTS OF INTEREST

Not stated

GUIDELINE STATUS

This is the current release of the guideline.

This guideline updates a previous version: Davis PC, Seidenwurm DJ, Brunberg JA, De La Paz RL, Dormont PD, Hackney DB, Jordan JE, Karis JP, Mukherji SK, Turski PA, Wippold FJ, Zimmermam RD, McDermot MW, Sloan MA, Expert Panel on Neurologic Imaging. Head trauma. [online publication]. Reston (VA): American College of Radiology (ACR); 2006. 12 p. [48 references]

The appropriateness criteria are reviewed annually and updated by the panels as needed, depending on introduction of new and highly significant scientific evidence.

GUIDELINE AVAILABILITY

Electronic copies: Available in Portable Document Format (PDF) from the American College of Radiology (ACR) Web site.

ACR Appropriateness Criteria® *Anytime*, *Anywhere*™ (PDA application). Available from the ACR Web site.

Print copies: Available from the American College of Radiology, 1891 Preston White Drive, Reston, VA 20191. Telephone: (703) 648-8900.

AVAILABILITY OF COMPANION DOCUMENTS

The following are available:

- ACR Appropriateness Criteria®. Background and development. Reston (VA): American College of Radiology; 2 p. Electronic copies: Available in Portable Document Format (PDF) from the American College of Radiology (ACR) Web site.
- ACR Appropriateness Criteria® radiation dose assessment introduction. American College of Radiology. 2 p. Electronic copies: Available from the American College of Radiology Web site.

PATIENT RESOURCES

None available

NGC STATUS

This summary was completed by ECRI on July 31, 2001. The information was verified by the guideline developer as of August 24, 2001. This NGC summary was updated by ECRI on August 11, 2006. This NGC summary was updated by ECRI Institute on July 1, 2009.

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